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Indian Standard

IS 15883 (Part 8) : 2015
(Reaffirmed 2020)

निर्माण परियोजना प्रबंधन — दिशानिर्देश

भाग 8 जोखिम प्रबंधन

Construction Project Management — Guidelines

Part 8 Risk Management

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Construction Management (Including Safety in Construction) Sectional Committee, CED 29

FOREWORD

This Indian Standard (Part 8) was adopted by the Bureau of Indian Standards, after the draft finalized by the Construction Management (Including Safety in Construction) Sectional Committee had been approved by the Civil Engineering Division Council.

A construction project is an endeavour undertaken by a project team on behalf of owner/client to create a built facility suited to the defined functional objectives. From inception to commissioning, the project goes through various distinct stages leading to progressive achievement of project objectives. Each stage involves specific inputs, processes (both technical and managerial) and deliverables. Typically, the life cycle of a project from commencement to completion involves the following stages:

a) *Project appraisal* – Inception, feasibility and strategic planning;
b) *Project development* – Project brief development, planning and design, finalization of proposals, procurement strategy, construction documentation including tender drawings, construction drawings, specifications, cost estimates, bills of quantities, procurement documents;
c) *Planning for construction* – Sequencing of project components, planning tools, resource planning and time cost trade off;
d) *Tender action* – Open competitive bidding/pre-qualification of agencies, issue of tender documents, evaluation of bids, negotiation if required and award of work;
e) *Construction* – Execution, monitoring, control, work acceptance; and
f) *Commissioning and handing over* – Contractual closeout, financial closeout, defect liability commencement, facility handing over.

The distinct features of a construction project include the temporary nature of the project team involved, the evolutionary process of project deliverables during project development stages and the unique output as the built facility. As a result of these features, unless there is efficient and effective project management, a construction project is faced with challenges of uncertainties leading to time over-runs, cost over-runs, changes in project parameters, loss of quality and inability to meet the functional objectives. While technical soundness of a proposal is an important aspect of a construction project, the management aspects, which involve techno-legal, financial and other issues, have also a significant role in the success of a project. Therefore, management functions and technical processes in a construction project need to be integrated towards achieving project objectives. Top management commitment plays an important role in harmoniously achieving these project objectives. In some of the public domain projects, it may be necessary to share relevant information with public at large through appropriate means.

To provide necessary guidance on effective construction project management, a series of standards are being developed as part of IS 15883 'Guidelines for Construction project management'. Part 1 General, of the standard since published as IS 15883 (Part 1) : 2009, covers general aspects of overall construction project management. This has been followed by publication of other parts as follows:

Part 2 : 2013	Time management
Part 3 : 2015	Cost management
Part 4 : 2015	Quality management
Part 5 : 2013	Health and safety management
Part 6 : 2015	Scope management

The other parts of the standard are under formulation which will cover functions such as procurement management, communication management, human resource management, sustainability management and integration management.

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Indian Standard

CONSTRUCTION PROJECT MANAGEMENT — GUIDELINES

PART 8 RISK MANAGEMENT

1 SCOPE

1.1 This standard (Part 8) covers guidelines for risk management aspects of construction project management.

1.2 The risk management aspects during the project formulation and appraisal stage of the project are not covered in this standard. The scope of this standard, therefore, covers the stages subsequent to the stage of approval (when a decision to implement the project including its financing is taken) till commissioning and handing over of the project.

1.3 The provisions of this standard are to be read in conjunction with IS 15883 (Part 1).

2 REFERENCES

The standards given below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
7337 : 2010	Glossary of terms in project management (*second revision*)
10400 : 2013	Glossary of terms in inventory management (*second revision*)
15198 : 2014	Glossary of terms in human resource development (*first revision*)
15883	Construction project management – Guidelines
(Part 1) : 2009	General
(Part 2) : 2013	Time management
(Part 3) : 2015	Cost management

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 7337, IS 10400 and IS 15198 shall apply.

4 GENERAL

4.1 General Aspects Relating to Risk and Risk Management

Generally risk is considered as exposure to a danger or hazard and is viewed as 'negative'. However, risk could be both, a mix of danger and opportunity.

Project risk management is the art and science of identifying, assessing and responding to project risks throughout the life of a project and in the best interests of its objectives namely, project completion within estimated time and cost and to the required specifications and quality standards. The constant goal of project risk management should be to minimise uncertainties and move towards opportunities. The goals of risk management, therefore, are to identify project risks and to develop strategies, which either reduce them or attempt to avoid them so as to achieve the project objectives.

All projects have associated risks which need to be identified during all stages of the construction project. Some risks are independent risks and some risks may be inter-related or dependent risks. There is a need to quantify the risks in terms of likelihood of their occurrence and their impacts on the project objectives. For inter-related or dependent risks, it should be anticipated how one risk occurrence may affect probability of occurrence of another. The response to one risk may also alter the consequences of or the probabilities of occurrence of the other risks or the response to one risk may impact the project's ability to respond to another risk as both may require same resources. Project risk management is not only for corporations or public organisations, but for each activity of the project whether of short or long duration. The benefits and opportunities should be viewed not just in the context of the activity itself but in relation to the many and varied stakeholders who can be affected.

The risk analysis and management process needs to address the following:

a) Identification of risks;
b) Probability of occurrence of identified risks;
c) Likely impact of risks on the project in terms of time, cost and quality;
d) Risk responses and their cost to the project;
e) Understanding that how responses to certain risks would lead to other risks;
f) Methodologies to reduce or eliminate the losses; and
g) Management setup to deal with risks.

To achieve the objective of above explained risk analysis and management process, following steps need to be taken:

1) Risk management planning;
2) Risk identification;
3) Risk assessment;
4) Risk response planning;
5) Risk monitoring and control; and
6) Risk management feedback and lessons learnt.

All these steps are discussed in detail in the subsequent sections.

In construction project management, a risk is some future happening that results in a change, either positive or negative, to the project. However, for the most part, it is associated with loss. The loss can be estimated and is a combination of the following two factors:

i) The probability that the event will occur; and
ii) The severity of the loss, if the event occurs.

This estimate forces a choice on the project manager's part regarding what to do, how to mitigate the risk and ascertain the loss that may occur. At project level a standard approach is needed to ensure that there is an agreed: objective for risk management, definitions and terminologies related to risk management, process by which risk management can be carried out, and organisation structure for risk management.

There are many ways of achieving the objectives of risk management. These would vary with the scale, nature and complexity of projects. This standard is prescriptive in nature and the generic approach described herein provides the principles and guidelines for managing any form of risk in a systematic, transparent and credible manner within any scope and context. By meeting the various provisions of this standard, though in different ways, project teams will be in a position to report that they are in compliance and they can benchmark their risk management practices.

4.2 Anticipated Risks at different Stages of Construction Projects

a) *Pre-construction Stage* – Anticipated risks during pre-construction stage, may be,

1) inadequate soil and other required investigations and surveys;
2) inadequate detailed project reports (DPRs) including inadequate cost estimates;
3) delay in project specific clearances including environmental clearances;
4) inadequate handling of social issues;
5) incomplete/inadequate project drawings and documents;
6) inappropriate technology adoption decision;
7) unrealistic project schedules and inadequate programme scheduling;
8) lack of proper study of project documents; and
9) inadequate project tenders and bidder response.

b) *Construction stage* – Anticipated risks during construction stage, may be,

1) land acquisition and non-availability of site free of encumbrances;
2) organisational inter-disciplinary interfaces;
3) variations in geotechnical conditions;
4) delay in issue of 'good for construction drawings';
5) design variations and other changes by consultants, client and other stakeholders;
6) variations in construction programme;
7) non-availability/shortage of adequate resources including manpower, material and machines;
8) lack of commitment/co-ordination by various stakeholders/project participants;
9) lack of team work and inter-disciplinary interfaces;
10) lack of commitment and leadership skills in senior management;
11) inadequate disputes' settlement mechanism;
12) lack of awareness of safety norms and lack of implementation of safety requirements;
13) accidents;
14) multiplicity of laws to be followed and delay in project specific clearances required at the construction stage;
15) inefficient payment system/paucity of funds;
16) ineffective contract management;
17) interpretation of contract clauses;
18) law and order issues;
19) currency fluctuation;
20) political uncertainty;
21) unpredictable weather conditions;
22) lack of transportation and infrastructure availability;
23) force majeure; and
24) change in statutory stipulations.

c) *Commissioning and handing over stage* – Anticipated risks during commissioning and handing over stage, may be related to,

1) final payments and related settlements;

2) contract closure;
3) final project documentation;
4) final disputes resolution;
5) political interference/public pressure; and
6) concessionaire's apathy (if applicable).

Risks listed above are indicative only and could be identified in detail for each specific project.

4.3 Organizational Structure for Risk Management

Organizational structure for risk management is defined by the size, characteristics and criticality of a project.

Depending upon the size, nature and complexity of the project, risk management team shall comprise either the project execution team and/or a group of project stakeholders. Their role, accountability and reporting structure shall be well defined and documented.

For small to medium size projects, risk management could be conducted by the project team. But, for large and critical projects, risk management would be conducted by specialized in-house team or through consultant(s).

5 RISK MANAGEMENT

5.1 Risk Management Planning

Risk management planning is the process of defining how to conduct risk management activities for a project. Careful and explicit planning enhances the probability of success of project risk management. Planning risk management processes is important to ensure that the degree, type and visibility of risk management is commensurate with both the perceived risks and criticality and complexity of the project. Planning is also important to provide sufficient resources and time for risk management activities, and to establish an agreed approach amongst the project stakeholders for risk identification, assessment, monitoring and control. Risk management planning is the process to enable formulation of risk management team structure, identification of tools and techniques to be used for risk management, documentation for monitoring and control of risk management processes.

5.1.1 *Risk Management Planning: Required Information*

The required information for risk management planning includes the following:

a) *Project scope,* including all activities associated with the project for its delivery as per the defined objectives.
b) Time management plan [*see* IS15883 (Part 2)].
c) *Cost management plan* [*see* IS15883 (Part 3)].
d) *Information and communications management plan*, including interactions that shall occur on the project and modes thereof.
e) *Procurement management plan*, including processes for purchase of materials, equipment, products, soliciting services of consultants and engaging agencies for execution of works under a contract with special provisions with respect to risk management.
f) *Quality management plan*, including planning, direction and control for issues with respect to risk management.
g) *Human resource management plan*, including skills, roles and responsibilities required for risk management.
h) *Health, safety and environment plan,* including all the issues with respect to risk management.
j) *Project environment***,** that can influence the risk management planning process with respect to the risk attitudes and the tolerances that describe the degree of risk which project stakeholders have to withstand.

Following aspects of constituent stakeholders' organizational elements shall also be considered in risk management planning:

1) Risk categories,
2) Definitions and terminologies related to risk management,
3) Risk statement formats,
4) Standard templates,
5) Roles and responsibilities,
6) Authority levels for decision-making, and
7) Lessons learnt.

5.1.2 *Planning Meetings and Analysis*

Project teams hold planning meetings to develop the risk management plan. Attendees at these meetings need to include the project manager, selected project team members, authorized representatives of stakeholders and others as needed. The outputs of these meetings shall be summarized in the form of a risk management plan.

5.1.3 *Risk Management Plan*

The risk management plan describes how risk management shall be structured and performed on the project shall include at least the following elements:

a) *Methodology* — It defines the approaches, tools, and data sources that may be used to perform risk management on the project.
b) *Roles and responsibilities* — It defines the lead, support, and risk management team members for each type of activity in the risk management

plan, and assigns their authorities and responsibilities.

c) *Risk categories* — It provides a structure that ensures a comprehensive process of systematically identifying risks to a consistent level of detail and contributes to the effectiveness and quality of the process of identification of risks which shall lead to the preparation of the risk breakdown structure (RBS). The RBS is an hierarchically organized depiction of the identified project risk arranged by risk category and subcategory that identifies the various areas and causes of potential risks.

d) *Risk budget* — It assigns resources, estimates funds needed for risk management for inclusion in the cost performance baseline, and establishes protocols for application of contingency and management reserves.

e) *Schedule for risk management processes* — It defines when and how often the risk management processes will be performed throughout the project life cycle, establishes risk management activities to be included in the project schedule and establishes protocols for application of schedule contingency reserves.

f) *Project tolerances* — It establishes project baseline tolerances acceptable to project stakeholders.

g) *Definitions of risk probability and impact* — The quality and credibility of the risk assessment process requires that probabilities of occurrence of different levels of risks and their impacts be defined. General definitions of probability levels and impact levels are tailored to the project.

h) *Probability and impact matrix* — Risks are prioritized according to their potential implications for having an impact on the objectives of the project. A typical approach to prioritizing risks is to use a probability and impact matrix. The specific combinations of probability and impact that lead to a risk being rated as high, moderate, or low importance are established at this stage.

j) *Reporting formats and communication* — It defines how the outcomes of the risk management processes shall be documented, analyzed, and communicated. It describes the content and format of the risk register as well as any other risk reports required.

k) *Risk monitoring* — It establishes risk tracking and monitoring processes.

m) *Risk auditing* — It documents how risk activities shall be recorded for the benefit of the current project as well as for future needs and lessons learned, and whether and how risk management processes shall be audited.

5.2 Risk Identification

To manage risks in a project, once the risk management plan has been completed, all anticipated risks shall be identified. The objectives of risk identification are to identify and categorize risks that can affect the project, and to then document these risks. The outcome of this step is a comprehensive list of risks based upon historical review (past), present project assessment (present) and assessment of future project risks by applying creative tools and techniques (future). This process should include identification of,

a) sources of risks irrespective of whether these are under control of the project team;
b) areas of impact due to these risks; and
c) their causes and potential consequences.

Comprehensive risk identification is critical, though identification of all possible risks at the outset of a project may not be possible. The objective is to identify all risks to the maximum possible extent. Identified project risks may change as project progresses through its life cycle. This may be due to actions or decisions taken during project execution to handle project internal changes or externally imposed changes.

5.2.1 *Risk Identification Process*

Following describe the best practices for identifying risks, which enhance the likelihood of identification of as many risks as possible:

a) *Identification to start at an early stage in the project life cycle* — Early identification of the risks helps to take key project decisions that may define the project strategy. It also maximizes the time available to plan and implement the risk response.

b) *Identification be comprehensive* — All possible sources of risk or risk categories for a construction project shall be considered to identify the risks.

c) *Encourage creative thinking* — The risk identification process should promote creative thinking and leverage team experience and knowledge.

d) *Involvement of broad range of stakeholders* — For identifying risks, taking input from broad range of stakeholders ensures that all perspectives of the project are represented and considered. Risk identification should not limit to immediate project team members only.

e) *Identification of possible risk sources* — Identification should include risks whether or not their source is under the control of the project team. Some of the possible risk sources for construction projects are listed in **4.2**. List is not exhaustive and should be arrived at depending upon the project peculiarities.

f) *Risks to be linked to project objectives* — All identified risks should be linked to one or more project objectives: project cost, time, scope, quality, etc.

g) *Risk categorisation and risk breakdown structure* — The identified risks may be further categorized based upon sources of risks, area of impact of risks, project phases or as per any other parameter considered relevant for the project. This shall lead to preparation of risk breakdown structure. It is an hierarchically organized depiction of the identified project risks arranged by risk category and subcategory that identifies the various areas and causes of potential risks.

h) *Project documents review* — Risks can be identified and derived from an examination of the project documents and details including description, work breakdown structure, cost estimate, design and construction schedule, procurement plan or quality plan.

j) *A clear and complete risk statement* — All identified risks shall be clearly described so that these can be well understood for further risk assessment and response planning. Single word like, 'contract', 'infrastructure' or an ambiguous statement should be avoided for any miscommunication.

k) *Risk trigger* — For each identified risk, a suitable risk trigger or symptom shall be defined which indicates its occurrence in the project.

m) *Risk ownership* — Each identified risk shall be assigned to a single identified owner with clear responsibility and accountability to manage it further.

n) *Documentation* — All identified risks shall be formally recorded in a form of table that is risk register or any other suitable format in order to document all relevant information currently available for the identified risks. A template of possible risk register is given in Annex A.

p) *Identification to be an iterative process* — As it is impossible to identify all risks at one time in a project, risk identification process should be done repeatedly throughout the project lifecycle, that is, from project appraisal stage till commissioning stage. Frequency of risk identification shall be determined during the risk management plan.

q) *Identification of secondary risks and residual risk* — See **5.4.2** and **5.4.3**.

r) *Risk response planning to identify responses to mitigate identified risks* — It is not practically possible to mitigate all risks and project shall always be executed with certain 'residual risks' that may affect the project. Also, implementation of certain risk response strategies may generate new risks which are termed as 'secondary risks'. Thus, during risk monitoring and control process, new risks, residual risks and secondary risks shall be identified, included in the risk register and assigned risk owners for necessary action.

s) *Identification not to limit to any formal event or regular review* — In addition to the frequency or event that is defined during risk management plan for risk identification process, identification of the risk can be done at any time whenever it is required.

5.2.2 *Risk Identification Tools and Techniques*

The project team should apply risk identification tools and techniques that are appropriate to its objectives and capabilities, and also to the nature and type of project risks faced. Following are some simple risk identification tools:

a) *Documentation review* — A structured review of project documentation including that of previous similar projects. This information may include risk audit information, variance and trend analysis information and other information of previous similar projects which may help to identify risks in the project being planned.

b) *Brain storming* — This is an information gathering technique by group discussion. Goal is to obtain a comprehensive list of project risks. Ideas about project risks are generated under the leadership of a facilitator.

c) *Delphi technique* — This is similar to brainstorming but participants are anonymous. A facilitator uses a questionnaire and circulates to experts. Responses are submitted and assessed. Consensus is reached after few rounds of this process.

d) *Interviewing* — This is performed by talking individually or in group with experienced project team members, stakeholders or subject matter experts. These interviews can be done informally or formally based on the prepared questionnaire.

e) *Assumption analysis* — It explores the validity of assumptions as they apply to the project. Inaccuracy, instability, inconsistency or incompleteness of assumptions identifies risks. This may include 'what-if analysis' to be conducted regarding project scenarios.

f) *Strengths, weaknesses, opportunities and threat (SWOT) analysis* — Assessment of strengths and/or weaknesses of an organization or project team, focusing on either the project organization or the wider business opportunities and threats are identified using brain storming.

5.3 Risk Assessment

Risk assessment evaluates characteristics of individually identified project risks and prioritizes risks based on agreed-upon parameters. It shall includes,

a) evaluating the probability or likelihood of each risk occurring, and

b) impact of each individual risk either enhancing or threatening the achievement of project objectives.

Risk assessment may be performed qualitatively and/ or quantitatively. Qualitative risk assessment process evaluates likelihood and impact of each individual risk. Quantitative risk assessment analyses overall risk to the project objectives that results from the combined effect of all risks and their potential interactions with each other.

5.3.1 *Qualitative Risk Assessment*

A project faces multiple risks. Thus, risks categorization and understanding of relationships between risks leads to improved analysis of the probability and magnitude of impacts, which helps in effective response planning. This shall include the following:

a) *Risks categorization based on their sources or corresponding risk hazards or causes* — This lead to the identification of 'root causes' or causes from which several risks or a group of risks arise. This may reveal the magnitude of the risk event for the group as a whole.

b) *Identifying common effects or impacts of risks* — This may lead to the identification of the areas of greatest exposure like project time, cost or quality.

c) *Identifying causal chain between the linked risks* — Understanding the chain of risks may lead to a better understanding of the likelihood and impact of the project risk.

d) *Identifying risks that can occur at the same time or using the same resources for recovery* — This may provide a realistic picture of problems of risk mitigation using scarce resources.

Qualitative risk analysis should lead to the following output information:

1) *Prioritization of risks* — This information is an input for plan risk response process. The criteria for risk prioritization shall be as agreed upon during the plan risk management process.

2) *Identification of activities that exhibit more risks* — This is identified by combining qualitative risk analysis information with work breakdown structure.

3) Identification of activities that may lead to the risk impact on a specific project objective.

4) Risk sources from which a cluster or group of risks originate.

This information shall be used for further finalizing the risk register (*see* Annex A).

There are various techniques that may be used for qualitative risk analysis. Some of these are as follows:

i) *Root cause analysis* — It is a tool for identifying the factors that resulted in the nature, the magnitude, the location, and the timing of the harmful outcomes (consequences) of one or more past events in order to identify what behaviours, actions, inactions, or conditions should be changed to prevent recurrence of similar harmful outcomes and to identify the lessons to be learned to promote the achievement of better consequences. It is a team effort and for risk assessment, it will be effective if the definitions for probability and impact of risks are agreed upon between all the project stakeholders.

ii) *Documentation review* — It is structured review of project documentation including previous project files, and other information which helps to identify the risk in the project

iii) *Probability and impact matrix* — It is a tool utilised to categorize risks based on their severity (*see* Annex B).

iv) *Analytic hierarchy process* (AHP) — It is a structured technique for organizing and analyzing complex decisions through group decision making process. Rather than prescribing a 'correct' decision, the AHP helps decision makers find one decision that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

5.3.2 *Risk Likelihood, Impact and Consequence*

5.3.2.1 Risk likelihood is the probability that a hazard or risk factor may actually materialize. It may be expressed as follows:

a) A qualitative rating such as high, medium or low; or

b) A numerical value between 1.0 (certain to happen) and 0 (impossible).

These ratings are subjective and depend upon the opinion of managers. Qualitative ratings may also be associated with certain numerical values as shown below:

Qualitative	*Numerical Values*
Low	0 – 0.20
Medium	0.21 – 0.50
High	0.51 – 1.00

The association between qualitative ratings and numerical values is subjective and depends on the type of project, experience of the project team and the risk tolerance of stakeholders.

5.3.2.2 Risk Impact is the effect of the materialization of a risk hazard. It is specified in terms of time, cost and performance measures. It can be expressed as,

a) qualitative rating such as high, medium and low, or

b) numerical value between 1.0 (catastrophic) and 0 (not serious).

These ratings are subjective. Qualitative ratings may also be associated with numerical values and the association is subjective. Risk impacts may also be classified as under:

1) Impact of a risk on specific project objectives,
2) Impact of a risk on the overall project, and
3) Impact of a risk beyond the project on the enterprise or organization executing the project.

5.3.2.3 Risk or risk consequence is defined as a function of risk likelihood and risk impact. It can be expressed in two ways:

a) As a simple numerical rating ranging between 0 and 1.0 (*see* Annex C).

b) As an expected value with respect to project objectives, that is, project time or cost (*see* Annex D).

5.3.3 *Qualitative Risk Assessment for Multiple, Independent Risks*

When a project is facing multiple, independent risk sources, a common likelihood factor (CLF) for the project shall be assessed. Similarly, for assessing the cumulative impact of all the risks a common impact factor (CIF) shall be calculated for the project. This leads to quantification of risk for the project in terms of risk consequence (RCR).

$$RCR = CLF + CIF - CLF(CIF)$$

Annex C explains the method of calculating CLF, CIF and RCR.

5.3.4 *Quantitative Risk Assessment*

Quantitative risk assessment seeks to determine the overall risk to project objectives when all risks potentially operate simultaneously on the project. It provides a numerical estimate of the overall effect of risk on the objectives of the project, based on current plans and information, when considering risks simultaneously. It helps in establishing contingency reserves, usually for time and cost that are appropriate to both, the risks and risk tolerance of project stakeholders.

Quantitative risk assessment by utilization of probabilistic techniques like Monte Carlo simulation, provides realism in the estimate of the overall project cost or schedule. A non-probabilistic approach assumes that the activity durations or cost estimates are deterministic. The basis for quantitative risk assessment is an appropriate model of the project, which may include project time schedule, cost estimates, decision tree (for decisions in the scenario of uncertainty) and other information to depict total project.

However, quantitative assessment is not always required or appropriate for all projects especially for smaller projects. Therefore, during the risk management planning process (*see* **5.1**), the benefits of quantitative risk analysis should be weighed against the effort required to ensure that the additional insights and value justify the additional effort.

Quantitative risk analysis leads to the following output information:

a) Likelihood of the project to complete on the schedule date or earlier, and the project actual cost to be the budgeted cost or less.

b) Extent of contingency in time and cost needed to provide the organization with its desired degree of confidence in the results; and if the contingency reserve required exceeds the time or resources available, the required changes needed to be done in project scope and plan.

c) Extent of reliability of the product that the project produces and how should the design of the product or system be changed most economically to increase its reliability.

d) The best decision to make in the face of uncertain results.

e) The individual risks that seem to be the most important in determining the overall project risk.

f) Project activities associated with most important risks; this can be identified by sensitivity analysis in a cost risk analysis or a criticality analysis in a schedule risk analysis.

There are various techniques that may be used for quantitative risk analysis. Some of these are:

1) *Decision tree analysis* — It is a tool used for decision making. It allows the user to specify the structure of the decision with decision nodes, chance nodes, costs, benefits and probabilities. Different decisions can be evaluated using linear utility functions based on expected monetary value (described below) or on non-linear utility functions of various shapes.

2) *Expected monetary value (EMV)* — This is a simple calculation of a value such as weighted average or expected cost or benefit when the outcomes are uncertain. All reasonable alternative outcomes are identified. Their probabilities of occurring (summing to 100 percent) and their values are estimated. The EMV calculation is made for the entire event by weighting the individual possible outcomes by their probabilities of occurring.

3) *Fault tree analysis* — It is a top down, deductive failure analysis technique in which an undesired state of a system is analyzed using boolean logic to combine a series of lower-level events. This analysis method is mainly used to determine the probability of a particular system level (functional) failure.

4) *Monte Carlo simulation* — It is a detailed, computer-intensive simulation approach to determine the value and probability of possible outcomes of a project objective such as a project schedule or cost estimate.

5) *Documentation review* — A structured review of project documentation including previous project files, and other information which helps to identify the risk in the project.

6) *System dynamics* — It is an approach to understand the behaviour of complex systems over time. It deals with internal feedback loops and time delays that affect the behaviour of the entire system. What makes using system dynamics different from other approaches to studying complex systems is the use of feedback loops and stocks and flows. These elements help describe how even seemingly simple systems display nonlinearity.

7) *Sensitivity analysis* — This is an approach to study different project scenarios in terms of probability of their occurrence.

5.3.5 The following are some other points that should be considered during risk assessment:

a) During risk management planning, the risk management team should define the levels of probability and of impact on objectives, which would be required for risk assessment.

b) Data collected for risk assessment should be reliable and of high quality. It should also be unbiased.

c) Risk assessment for individual risks should be performed periodically throughout the project. The frequency of this process shall be planned in the risk management planning process, but may also depend on events within the project itself.

The risk assessment process is depicted in Fig. 1.

5.4 Risk Response Planning

Risk assessment and risks categorization of all identified risks leads to risk response plans formulation. These will comprise a report on identified risks and recommended actions for reducing the probability of occurrence of these risks and minimizing the impact of risks if they occur.

For negative risks, recommended actions shall fall under any, some or all of the following categories:

a) *Hold or retain or accept* — Low category risks may be retained or accepted by the project execution team and dealt with during project execution. For such risks, there shall be a fall back plan to be implemented, if the risk affects the project. For example, unanticipated increase in cost of material.

b) *Reduce* — This action shall apply to those risks for which we can reduce the probability of their occurrence and impact, if they occur. Some of these actions may be modifying the design specifications, working methodologies and procurement strategies.

c) *Share* — Risks can be shared by the project team with other entities where mutual incentives are recognized. Some of these risk sharing mechanisms may be sub-contracting and joint ventures.

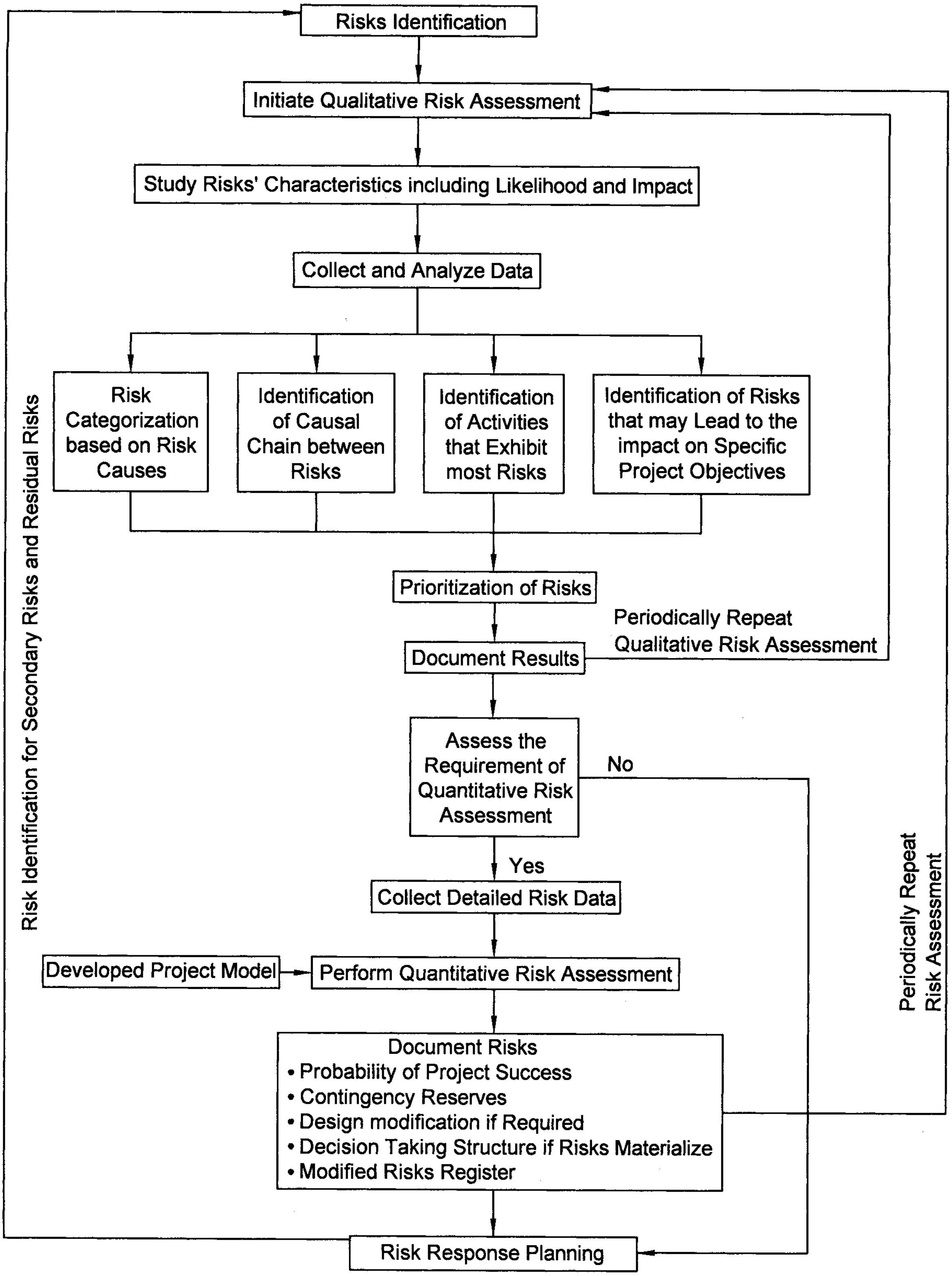
Risks Identification
Initiate Qualitative Risk Assessment
Study Risks' Characteristics including Likelihood and Impact
Collect and Analyze Data
Risk Categorization based on Risk Causes
Identification of Causal Chain between Risks
Identification of Activities that Exhibit most Risks
Identification of Risks that may Lead to the impact on Specific Project Objectives
Prioritization of Risks
Document Results
Periodically Repeat Qualitative Risk Assessment
Assess the Requirement of Quantitative Risk Assessment
No
Yes
Collect Detailed Risk Data
Developed Project Model
Perform Quantitative Risk Assessment
Document Risks
• Probability of Project Success
• Contingency Reserves
• Design modification if Required
• Decision Taking Structure if Risks Materialize
• Modified Risks Register
Risk Response Planning
Risk Identification for Secondary Risks and Residual Risks
Periodically Repeat Risk Assessment

FIG. 1 RISK ASSESSMENT PROCESS

d) *Transfer* — This action shall apply to those risks for which probability of occurrence cannot be reduced but impact can be minimized by transferring the liability to another entity through insurance or relevant contract clauses.

e) *Avoid* — This applies to high or extreme risks for which probability of occurrence and impact cannot be reduced. Such risks may be totally avoided, for example, changing the location of the project, changing specifications, technology and working methodologies.

Contingency reserves allocated for the project shall be utilized for above stated five risk response actions.

For positive risks, recommended actions shall fall under any, some or all of the following categories:

1) *Exploit* — Actions are taken so that opportunities may occur and project shall be able to take advantage of those opportunities. This includes strategically planning the project location near the location of sourcing resources.

2) *Share* — Benefits of positive risks are opportunities shared with agencies that are better placed to take the benefit of those opportunities. This includes executing a project through a joint venture where the profits are shared by all the agencies that constitute the joint venture.

3) *Enhance* — Actions are taken to increase the probability of opportunities occurring for the project or to increase their positive impact on the project. This may be achieved by changing the specifications, design elements or the structure of the project team.

4) *Accept* — Some opportunities may occur for the project and be accepted by the project execution team. For example, unanticipated change in cost of material. If the cost of material does not increase, it shall be beneficial for the project, but if it happens, that shall have negative impact on the project.

For each identified risk, possible risk response strategies shall be finalized, taking into account the cost of implementing those responses, resources and tools and techniques required to implement those responses, their impact on the project and the possible secondary and residual risks. Risk responses may be planned at the senior management level and implemented by the planning or execution team. Recommended risk response actions for each identified risk shall be included in the risk register (*see* Annex A).

Risk response strategy needs to be integrated with the overall project management plan to assess probability of its effective implementation, its efficacy in mitigating risks, expected post-response scenario and expected requirement of additional response strategies or fall back plan.

5.4.1 *Insurance Policies for Construction Projects*

Specific insurance policies are utilized for specific industries. Following insurance policies are applicable to construction projects:

a) *Contractor all risks (CAR) insurance* — It is applicable for construction and maintenance period of construction projects like roads, buildings, bridges, etc. It covers insurance cover for damage or loss of the object that is being insured. It also includes third party liability during construction period covering labour insurance.

b) *Erection all risks (EAR) insurance* — It is applicable for erection and maintenance period of projects like factory equipment installation, antenna installation, etc. It covers insurance for object's damage or loss that is being insured. It also includes third party liability during erection period.

c) *Electronic equipment (EEI) insurance* — It covers electronic equipment damage or loss caused to them by external hazard such as short circuit, fire, etc. For example, television studio equipment insurance, CCTV, telecommunication equipments, etc.

d) *Machinery breakdown (MB) insurance* — It covers machinery breakdown damage or loss caused by it and not from external hazard. For example, factory machinery insurance, refrigerator, etc.

e) *Loss of profit following machinery breakdown (MLOP) insurance* — It covers the loss of gross profit that occurs from machinery breakdown, refrigerator and other machineries insured under MB Insurance.

f) *Boiler and pressure vessel (BPV) insurance* — It covers the loss from boiler explosion or pressure vessel. The insurance includes the damage from the object of the insured, the damage from the property of the insured, and third party liability either on physical or property damage.

g) *Deterioration of stock (DOS) insurance* — It covers the loss from goods deterioration inside cold storage caused by cold engine. In order to have a claim settlement for this insurance, the cold engine shall have to be insured with MB insurance.

h) *Civil engineering completed risk (CECR) insurance* — It covers for finished civil engineering facility or structure being developed such as bridge, barrage, port, and other civil property. The insurance will cover for damage caused by fire, earthquake, flood, landslide, storm, etc.

j) *Contractor's plant and machinery (CPM) insurance* — CPM insurance covers for any damage or loss in heavy equipment used that is caused by collision, tumbling, burglary, natural disaster, etc. For example, insurance for tractors, excavator and bulldozer.

5.4.2 *Secondary Risks*

Implementation of certain risk responses may generate additional risks that are known as secondary risks. These identified secondary risks shall be assessed, included in the risk register; risk owners shall be assigned for these risks; and response strategies for these risks shall be planned for the project. Some of these secondary risks can be identified at the risk planning stage, but some of these risks may get identified at the risk monitoring and control stage.

For example, for transferring the risk of executing a project on time, within estimated cost and as per the quality specifications, the lead contractor of a project sub-contracts the project work to different agencies, who may further sub-contract their contracted work to other sub-contractor. This process increases the number of agencies executing the project and generates the secondary risk of effective coordination between all the agencies. Thus, response strategy is to plan for effective coordination between all the agencies.

5.4.3 *Residual Risks*

It is not possible to eliminate the probability of occurrence of all the risks or their impact on the project. Thus, even after formulating and implementing a risk response strategy, some risks remain for the project and are termed as residual risks, which are retained during the project execution stage. These identified residual risks shall be assessed, included in the risk register and risk owners shall be assigned for these risks. Priorities for these residual risks shall be identified and recorded. Some of these residual risks shall be identified at the risk planning stage, but some of these risks may get identified at the risk monitoring and control stage.

For example, unanticipated increase in cost of material can be residual risk for a project. At the start of the project, this risk cannot be eliminated, but there should be a fall back plan to be implemented if this risk affects the project.

5.5 Risk Monitoring and Control

Risk monitoring and control shall be performed throughout the project life cycle by the risk management team. It shall comprise the following steps:

a) Identification of new risks including secondary and residual risks;
b) Monitoring of previously identified risks;
c) Monitoring of risk response plans and their effectiveness;
d) Risk management plan updation;
e) Maintaining communication between the project team and risk management team; and
f) Comprehensive project documentation.

Depending upon the size, nature and complexity of project the periodicity of above steps shall be decided.

5.5.1 *Risk Monitoring Meetings*

While there may be a regular review for project implementation which can discuss risk monitoring, such meeting of stakeholders shall be convened early in case of emergency/high value risk. This will help in identifying suitable risk mitigation measures early resulting in less additional cost.

Risk monitoring team shall analyze the risks and their occurrence, trigger mechanisms and their usefulness and risk mitigation actions and their effectiveness.

5.5.2 *Risk Reports*

Risk monitoring reports may be prepared for the following parameters:

a) Identified and unidentified risks and their occurrence;
b) Risk mitigation action taken whether as originally envisaged or modified;
c) Expenditure, if incurred or likely to be incurred, over and above the contingency reserves earmarked;
d) Status update of closed risks; and
e) Feedback reports for above parameters.

5.5.3 *Sensitizing Project Team regarding Risk Awareness*

Periodically the project team and stakeholders shall be sensitized regarding the risks to the project and the benefits of risk management exercise being conducted.

5.5.4 *Alternative actions for Risk Monitoring*

Risk mitigation measures whether pre-decided or innovative when adopted, need to be reported to the risk management team through feedback and the concerned team members may be suitably rewarded.

5.5.5 *Replenishing Contingency Reserves*

Risk management team shall periodically monitor the expenditure from contingency reserves and trigger the mechanism for replenishment of contingency reserves, if required.

5.6 Post Construction Review and Documentation

All project risk management documents related to risks encountered and managed shall be analyzed and preserved for later reference.

ANNEX A

[*Clauses* 5.3.1(4) *and* 5.4]

A TYPICAL RISK REGISTER TEMPLATE

Organization Name :

Project Name:							**Project Manager's Name:**								
	Risk Identification				**Risk Assessment**					**Risk Response**			**Risk Monitoring & Control**		
					Impact (I)										
Risk Identification No.	**Risk Description**	**Risk Category**	**Risk Trigger**	**Risk Owner**	**Time**	**Cost**	**Performance**	**Probability(P)**	**Risk Factor (IxP)**	**Risk Response Action**	**Description of response action**	**Any alternative action**	**Risk Start Date**	**Risk End Date**	**Status**

ANNEX B

[*Clause* 5.3.1(iii)]

PROBABILITY-IMPACT MATRIX

B-1 Probability-impact matrix is generated to categorise the identified risks as per their severity. The probability of occurrence of risks may be measured on the following five point scale:

a) Very high,
b) High,
c) Moderate,
d) Low, and
e) Very low.

The impacts of identified risks may be measured on the following five point scale:

1) Severe,
2) Major,
3) Moderate,
4) Minor, and
5) Insignificant.

All the identified risks are accordingly placed in the probability-impact matrix and based on their severity categorized as,

i) Extreme risk,
ii) High risk,
iii) Moderate risk, and
iv) Low risk.

B-2 The following probability-impact matrix may be generated for the identified risk:

Probability	*Impact*				
	Insignificant	*Minor*	*Moderate*	*Major*	*Severe*
Very high	Moderate	High	High	Extreme	Extreme
High	Moderate	Moderate	High	High	Extreme
Moderate	Low	Moderate	Moderate	High	Extreme
Low	Low	Moderate	Moderate	Moderate	High
Very low	Low	Low	Moderate	Moderate	High

ANNEX C

[*Clauses* 5.3.2.3(a) *and* 5.3.3]

METHOD OF CALCULATING COMMON LIKELIHOOD FACTOR (CLF), COMMON IMPACT FACTOR (CIF) AND RISK CONSEQUENCE (RCR)

C-1 The method is explained below through a simple hypothetical example:

a) *Step 1* — Identify risk sources for the project and establish weightage for each risk source. Weightages of all risk sources should add up to 1.

Example: For a road project executed under build-operate-transfer (BOT) contractual arrangement, project risk sources and their respective weightages may be:

S_1 : Land acquisition ($W_1 = 0.6$)
S_2 : Funds ($W_2 = 0.4$)

b) *Step 2* — Identify risk situations or scenarios arising from each risk source.

Example:

S_1: *Land acquisition*

a) Land acquisition happens as planned
b) Land acquisition delayed due to administrative reasons
c) Land acquisition delayed due to political reasons
d) Land acquisition cancelled

S_2: *Funds*

a) Funds available
b) Funds stopped intermittently
c) Funds delayed

d) Funds stopped during project duration

c) *Step 3* — Identify failure likelihood due to each risk situation or scenario and select the most probable situation as is foreseen for the project.

Example:

	Likelihood
S_1: *Land acquisition*	
a) Land acquisition happens as planned	0 (low)
b) Land acquisition delayed due to administrative reasons	0.4 (moderate)
c) Land acquisition delayed due to political reasons	0.7 (significant)✓
d) Land acquisition cancelled	1 (high)

S_2: *Funds*

a) Funds available	0 (low)
b) Funds stopped intermittently	0.4 (moderate)✓
c) Funds delayed	0.7 (significant)
d) Funds stopped during project duration	1 (high)

d) *Step 4* — Calculate common likelihood factor (CLF).

Example:

$$\begin{aligned} \text{CLF} &= W_1 \times S_1\ \textit{Likelihood} + W_2 \times S_2\ \textit{Likelihood} \\ &= 0.6 \times 0.7 + 0.4 \times 0.4 \\ &= 0.58 \end{aligned}$$

e) *Step 5* — Identify risk impacts on the project and establish weightage of each impact.

Example: For such a project, risk impacts and their respective weightages may be:

I_1: Project delay ($W_1 = 0.6$)
I_2: Project cost overrun ($W_2 = 0.4$)

f) *Step 6* — Identify Impact situations or scenarios arising from each risk impact.

Example:

I_1: Project delay

- Negligible impact; compensated by schedule slack time
- Project delayed (up to 6 months)
- Project delayed (up to 12 months)
- Project delayed (more than 12 months)

I_2: Project cost over-run

- Within budget
- Upto 20 percent cost increase
- 20 percent – 50 percent cost increase
- Cost increase in excess of 50 percent

g) *Step 7* — Identify impact values due to each Impact situation or scenario and select the most probable situation as is foreseen for the project.

Example:

Impact

I_1: Project delay

- Negligible impact; compensated by schedule slack time	0.1 (low)
- Project delayed (up to 6 months)	0.4 (moderate) ✓
- Project delayed (up to 12 months)	0.7 (significant)
- Project delayed (more than 12 months)	0.9 (high)

I_2: Project cost overrun

- Within budget	0 (low)
- Up to 20 percent cost increase	0.4 (moderate) ✓
- 20 percent – 50 percent cost increase	0.7 (significant)
- Cost increase in excess of 50 percent	0.9 (high)

h) *Step 8* — Calculate common impact factor (CIF).

Example:

$$\begin{aligned} \text{CIF} &= (W_1) \times I_1\ \textit{Impact} + (W_2) \times I_2\ \textit{Impact} \\ &= 0.6 \times 0.4 + 0.4 \times 0.4 \\ &= 0.40 \end{aligned}$$

j) *Step 9* — Calculate risk consequence (RCR).

Example:

$$\begin{aligned} \text{RCR} &= \text{CLF} + \text{CIF} - \text{CLF} \times \text{CIF} \\ &= 0.58 + 0.40 - 0.58 \times 0.40 \\ &= 0.748 \end{aligned}$$

k) *Step 10* — Assess that for this particular project, Risk consequence of 0.748 signifies high, medium or low risk project.

ANNEX D

[*Clause* 5.3.2.3(b)]

METHOD OF CALCULATING RISK CONSEQUENCE AS AN EXPECTED VALUE

D-1 Risk consequence as an expected value can be interpreted as the average outcome, if the project was repeated a large number of times. It is computed as:

Risk consequence = (Impact) × (Likelihood)

Risk consequence may be calculated for each individual risk and also at the work breakdown structure element level, as illustrated in the following examples:

a) *Risk Consequence calculation for an individual risk:*

Suppose the likelihood of occurrence of a risk is 0.40 and if this risk materializes, the project gets delayed by 4 months and project cost escalated by an estimated ₹ 5 000 000. Thus, expected risk consequences for project time and cost are:

Risk consequence time (RT) = (4 months) × (0.4)
= 1.6 months

Risk consequence cost (RC) = (₹ 5 000 000) × (0.4)
= ₹ 2 000 000

Assume the baseline or targeted Project time and cost were 18 months and ₹ 100 000 000 respectively.

Expected project completion time (ET) = 18 + 1.6
= 19.6 months

Expected project completion cost (EC) =
₹ 100 000 000 + ₹ 2 000 000 = ₹ 102 000 000

b) *Risk consequence calculation at work breakdown structure (WBS) element level:*

Let us assume a project has eight work packages and for each of these WBS elements' cost escalation due to risk occurrence, risk likelihood, risk consequence cost, baseline cost and expected project completion cost data is as shown below:

Sl No.	*WBS Element*	*Cost Escalation* ₹	*Risk Likelihood*	*Risk Consequence Cost* ₹	*Baseline Cost* ₹	*Expected Project Completion Cost* ₹
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	A	20 000	0.2	4 000	1 000 000	1 004 000
ii)	B	10 000	0.4	4 000	4 000 000	4 004 000
iii)	C	20 000	0.3	6 000	3 000 000	3 006 000
iv)	D	35 000	0.4	14 000	5 000 000	5 014 000
v)	E	30 000	0.5	15 000	5 000 000	5 015 000
vi)	F	20 000	0.6	12 000	4 000 000	4 012 000
vii)	G	20 000	0.4	8 000	3 000 000	3 008 000
viii)	H	10 000	0.4	4 000	2 000 000	2 004 000
		TOTAL		**67 000**	**2 7 000 000**	**2 7 067 000**

Assumed data for each of the eight WBS elements namely, time over-run due to risk occurrence, risk likelihood, risk consequence time, baseline time and expected project completion time data is as shown below:

Sl No.	*WBS Element*	*Time Over-run* Weeks	*Risk Likelihood*	*Risk Consequence Time* Weeks	*Baseline Time* Weeks	*Expected Project Completion Time* Weeks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	A	1	0.2	0.2	3	3.2
ii)	B	1	0.4	0.4	3	3.4
iii)	C	2	0.3	0.6	4	4.6
iv)	D	2	0.4	0.8	5	5.8
v)	E	2	0.5	1.0	6	7.0
vi)	F	2	0.6	1.2	5	6.2
vii)	G	1	0.4	0.4	3	3.4
viii)	H	1	0.4	0.4	2	2.4

Baseline time for all WBS elements has not been totalled to arrive at the total project time as some WBS elements could also be executed simultaneously. From above data it can be concluded that if the risks associated with the project materialize project cost escalation would be by ` 67 000 and by updating the time schedule with ‘expected project completion time’ data for each WBS element the time over-run or delay for the total project can be calculated.

ANNEX E

(*Foreword*)

COMMITTEE COMPOSITION

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Organization	*Representative(s)*
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(*Continued from second cover*)

Risk management is a rapidly developing discipline and there are many and varied views and descriptions of what risk management involves, how it should be conducted and what it is for. Although the practice of risk management has been developed over time and within many sectors in order to meet diverse needs, the adoption of consistent processes within a comprehensive framework can help to ensure that risk is managed effectively, efficiently and coherently across an organization. This standard (Part 8) has, therefore, been formulated with the aim to provide guidelines for risk management of construction projects in all stages. Successful planning and execution of a project is dependent on effective risk management planning and its implementation.

This standard (Part 8) has been formulated to cover aspects on risk management as part of construction project management and information regarding the applicable tools and techniques. It gives guidelines on risk management planning, risk identification, risk assessment, risk response planning and risk monitoring and control as part of the risk management process. Users of this standard are encouraged to employ suitable risk management software as an aid to implement provisions of this standard.

The guidelines may be applicable in general to all construction projects. However, for smaller projects, the applicability of various provisions may be decided appropriately by the parties concerned.

The composition of the Committee responsible for formulation of this standard is given in Annex E.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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